TOWARDS STRATEGIC USE OF BPS TOOLS IN EGYPT

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ABSTRACT

This paper provides an overview of the use of building performance simulation (BPS) among the building design professionals in Egypt. To assess the situation and highlight the status and difficulties encounter in the usage and the needs for BPS tools, three workshops were held, in July and August 2010 in Cairo. The paper first presents a brief overview of the status of the use of BPS in practice then describes the methods used, including, surveys, interviews, tools testing, brainstorming sessions and discussions. Finally, the study presents recommendations for the process of developing and using performance simulation tools for building design support.

INTRODUCTION

In the conference proceedings, of the International Building Performance Simulation Association (IBPSA), there are many studies concerning the use of BPS in practice. The aim of those studies is to describe the uptake and define the challenges of integrating BPS techniques. This includes the study of Lam in Singapore (1993), Goncalves in Portugal (1993), Donn in New Zealand (1997), Plokker in the Netherlands (1997), Crawley et al. in the USA (1997), Dunovska et al in Czech Republic (1999), Mahdavi in Austria (2003) and Hopfe et al in the Netherlands (2005). Most those studies addressed two main topics:

1. The status and nature of the relevant design and building community, regarding professionals (skills and education) and buildings (regulation).
2. Tools limitations and their ability to be integrated in the design process and practice.

However, no previous discussions or assessments have addressed those two common topics in Egypt. In fact, with the advent of the new Egyptian Energy Standard, Fire Protection Code and the implementation of building rating systems in the Middle East many architectural and engineering consulting firms and schools have been motivated to explore the potential of using building performance simulation (BPS) in practice. Many firms are seeking expertise to develop in-house simulation modelling teams for code compliance or design optimisation. Therefore, this paper aims to establish a snapshot of the status and potenial future use of BPS tools in the Egyptian design community. The results of three workshops, aiming to identify problems and prioties of the design community, are reported. The barriers and difficulties of integrating BPS tools in practice were identified. The final objective is to formulate a map for the use of BPS in practice. Recommendations are presented addressing practice, academia and research.

BACKGROUND

Since Egypt's independence in 1952 and until now, the building sector has been depending on highly subsidized energy prices without developing any energy code to stimulate energy efficiency. Surprisingly, the oil embargo, led by Egypt in 1973, forced Western governments to encourage research and practice to adapt energy efficiency and use simulation to predict building performance. In contrast, the Egyptian political decision was to subsidize the energy that discouraged the design and research community from adapting energy conservation measures and integrate BPS into design.

Looking back to the last twenty years, we can find that the successive economic, social growth and climatic change have resulted in extrapolating energy consumption rates. Currently, the government subsidizes for its population of almost 84 million, 40% of which live below the poverty line. However, the globalization effect on the Egyptian society and the economic growth has resulted in a higher standard of living among Egyptians. The population and economic growth coupled with long hot summers nourished the demand for building space, comfort and services. Consequently, the built environment became strongly dependant on indoor environmental-control equipments, which raised the demand for energy (Fahmy, 2008). At the same time, the heavily subsidized energy has resulted in a great deal of energy inefficiency (Abdallah, H., 1995, EL Arabi 2002). Over time, the design community neglected environmental design considerations and the knowledge chain of traditional environmental design and constructions has been broken. Passive design strategies such as shading, orientation, massing, thermal mass, natural ventilation and lighting are no longer used and have been replaced by active (mechanical acclimatisation) design strategies.

Accordingly, the Egyptian government faced many energy related problems during the last five years. First, the Egyptian peak of oil production passed in

2007 (the peak of gas production is expected to pass in 2015). Secondly, the increasing oil prices threaten and create a large pressure on the energy subsidy policy. Thirdly, the government is facing peaking energy consumption rates, patterns, and several energy blackouts all-overs the country, especially during summer. Between 2001 and 2011, electricity consumption has been growing over 7-10 percent in the building sector. Led by the Egyptian National Institute of Planning (ENIP) many reports warn that the energy supply will not be able to meet demand by 2015. As a reaction to this trend, and in order to accommodate the prognosis, the Egyptian government imitated the French decision of 1974 and declared the commencement of the Egyptian nuclear power plants program. Driven by the desire to provide cheap electricity to its population, where more than 40% live below the poverty line, the government considered the nuclear solution as the easiest way to solve the energy problem rapidly and centrally.

However, postponing the investments into energy efficiency encouraged the private sector, NGOs, international cooperation projects and even governmental bodies. Despite that, the rising energy consumption was not formally curbed by the interest of energy conservation and environmental protection there is interest to act separately. In 2005, the United Nations Development Program (UNDP) granted the Egyptian Housing and Building Research Centre (HBRC) a grant to develop a residential and commercial energy standard (Huang 2003). Both standards are completed, published and could be applied on voluntary basis. In 2009, the Egyptian German Joint Committee (JCEE) on Energy Efficiency and Environmental protection organized a National Consultation Symposium discussing Egypt's Policies for Energy Efficiency in Buildings in Egypt Energy efficiency codes (Mourtada 2009). In 2009, the UNDP initiated a project to enforce the labelling of appliances. In addition, the Global Environmental Facility (GEF) has financed numerous grants projects promoting the use of efficient lighting equipment and compact fluorescent lamps in Egypt. In 2010, under the Ministry of Housing the Egyptian Green Building Council (EGBC) was established as part of the HBRC aiming to set the Green Pyramid Rating System (EGBC 2011). In April 2011, the EGBC organised an international summit in Cairo on cost-effective sustainable design and construction highlighting key developments, challenges and needs in the sustainable design and construction field of Egypt. EGBC published a public review draft and is currently working on building the first Productive, Low-cost & Environmentally friendly Village (PLEV) in Fayoum city (EGBC 2011). Similarly the Egyptian Earth Construction Association with help of the German Aid (GIZ) is aiming to build a prototype for affordable housing in New Cairo using BPS for design assessment. Also there are 10 registered LEED projects in Egypt in hand of local firms according to USGBC Directory.

On the other hand, the recent changes encouraged academia and research to embrace BPS techniques in teaching and research (Sabry 2010). However, a lack of knowledge is limiting the use of BPS techniques and tools in Egypt. For example, the lack of knowledge is forcing Egyptian architectural firms to outsource the simulation work (energy performance, comfort, ventilation and daylighting) to foreign consultants when requested to deliver LEED certified buildings by multinational companies. This makes the use of BPS very limited. Therefore, the author announced three workshops in Cairo in summer 2010.

STRUCTURE OF THE WORKSHOPS

The workshops title was "Introduction to Building Energy Modelling". The use of BPS tools was promoted as an innovative process in the Egyptian design practice. The overall objective of the three workshops was formulating recommendations that will support a wide use of BPS tools in the Egyptian practice. As a reaction to the announcement, the author combined three groups resulting in three workshops. The first workshop consisted of 5 architecture and 3 mechanical engineering academics aiming to use BPS in their curriculum. The second workshop consisted of 10 architects working on vernacular and traditional environmental design projects and wishes to use BPS to verify and assess their designs. The third workshop was a group of 5 mechanical and 5 architectural engineers working in professional design firms aiming to use BPS for LEED projects.

Participants were asked to identify the obstacles that prevent from using BPS tools in the Egyptian design practice and to generate ideas and wish lists for tools developers for potential future-simulation tools. The workshop focused on applications, integration, capabilities and user interfaces. Each workshop was three days. Participants were introduced to different BPS tools ranging from simple to detailed tools. The included tools were MIT Advisor, ECOTECT, OpenStudio Plug-in, HEED, IES VE Plug-in, HEED, DesignBuilder and EnergyPlus. The aim of introducing those tools was to expose participants to

Figure 1. Selection criteria of BPS tools (Attia 2011)

a wide variety of tools and document their feedback based on their experience. Participants had to run a simulation model with some simple input parameter, run simulation and interpret the output results. The first two days were dedicated to introduce participants to the BPS field and describe the BPS selection criteria according to Attia's criteria, as summarized and displayed in Figure 1 (Attia 2011). According to his classification BPS tools, most important capabilities are Intelligence, Usability, Integration, Interoperability and Adaptability with the design process. In addition, participants were trained to use and explore the previously listed tools. On the third day, participants were asked to:

- Set a priority and rank the selection criteria of BPS according to their needs (Figures 2)
- Create tools map (Figures 3)
- Create an input and output wish list
- List the tools limitations and their ability to be integrated in the Egyptian design process and practice. (Figures 5-9)

Additionally, the facilitator handed a questionnaire to participants daily to collect wider information on participants' background regarding their practice and design decision-making in relation to Egyptian context. Appendix B provides an overview of the main questions. The author designed the structure and content of the surveys based on international surveys that have conducted in different countries Lam (1993), Goncalves (1993), Donn (1997), Plokker (1997), Crawley et al.(1997), Dunovska et al (1999), Mahdavi (2003) and Hopfe et al (2005). At the end of the third day, participants were confronted with their combined questionnaires' answers and engaged in a round table discussion. The three workshops finding are presented in the following section.

RESULTS OF THE WORKSHOPS

The following sections summarize and groups the concepts and ideas generated in the three workshops.

Participants' Description

The pre-workshop questionnaire indicated that the usage of BPS was extremely low. The only exceptions were mechanical engineers who use HVAC sizing tools in design firms. The mechanical engineers in Workshop 3 had experience with Hap and Trace 700. Most other participants indicated that they were not aware of the existence of BPS tools and the usage was beyond the scope of their work. However, tools including Revit, CAD, SketchUp and other visualisation tools were used frequently by participants for drawings, design and rendering. Among all participants, natural lighting and ventilation, energy efficiency, acoustics, indoor quality and comfort were not verified in their design.

Ranking of Selection Criteria

Figure 2 ranks the selection criteria of BPS tools according to participant's priorities. The purpose of

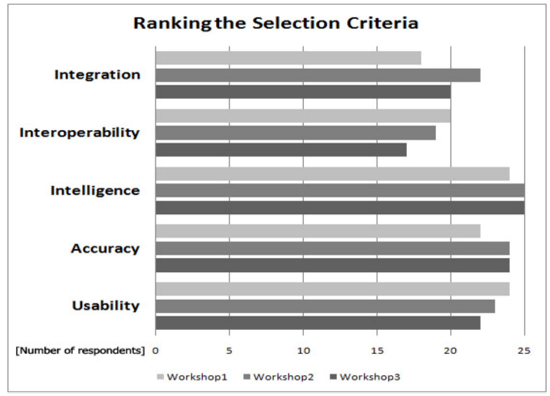

Figure 2, Ranking the Selection Criteria: Participants' responses ordered by workshops groups

this graph was to identify the user's selection criteria for BPS tools. Despite the limited use of BPS tools among Egyptian designers, participants were overwhelmed with the amount of available tools (almost 400 tools) when they were introduced to the U.S. Department of Energy Building Energy Software Tools Directory (BESTD) website (DOE 2010). Therefore, the workshops explained every criterion prior to the ranking process to make sure that participants understand the different aspects for choosing a BPS tool. The votes of participants were normalized, summed and plotted as percentage in Figure 2. Participants of the three workshops agreed to rank Intelligence in the first place followed by Accuracy and Usability. Participants agreed on the importance of Intelligence in any tool in order to inform the design and facilitate the decision-making. The Integration and Interoperability ranked last.

Tool Maps

In Figures 3, the tools maps are presented. In order to help participants to compare the tools usability and accuracy, participants were introduced to the study findings by Attia el al (2011) that ranks 10 analysis tools according to their accuracy. Participants were then asked to position design tools and analysis tools on a scatter plot, Figures 3. The x-axis represented the usability of the tool ranging from easy to difficult and the y-axis represented the Accuracy & Detail of the tool ranging from low to high. The aim of this graph was to examine the interoperability of simulation tools and integration with other design tools such as CAD. The discussion also revealed that all participants use CAD tools. Also all participants of workshop 3 use Revit (Architectural or MEP Suite) and are familiar with the BIM applications. The juxtaposition of the design and analysis tools in one graph created a debate on the design process and helped participants to define their expectation from future software packages. The most important argument was the need to find an accurate tool that can serve design and research and in the same time allows interoperability with drawing tools. There was a consensus to select EnergyPlus as a simulation engine. However, there were fewer consensuses on the interface and drawing tool that could be linked to EnergyPlus.Reasons for using BPS

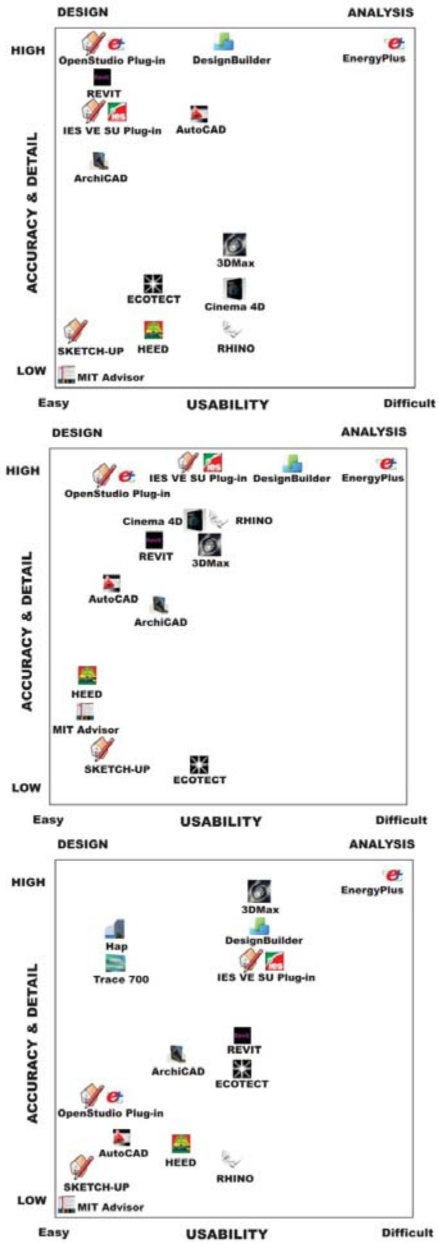

Figure 3a, b, c Tools Map of workshop 1, 2, 3

In Figure 4, participants prioritized the most important performance metric they expect from BPS according to three major issues:

- Performance issues (energy, natural ventilation, daylighting etc.)
- Occupants issues (comfort, indoor air quality)
- Cost return issues

Surprisingly, participants placed comfort on top. The discussion that followed the voting indicates that comfort is the most important commitment to clients in Egypt. The issue of energy is not of great importance because energy is cheap and there is no enforcement of the energy standard. Therefore, the cost return metric followed the comfort metric. However, participants of Workshop 3 pointed that they ranked the energy criteria in second place due to the obligation of LEED projects for minimum energy performance and in particular the ASHRAE 90.1 - 2007.

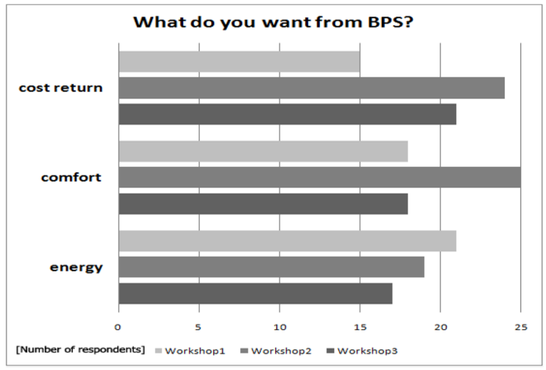

Figure 4, Participants' responses the most important feedback expected from BPS

Input and output wish list

The following question was an open-ended question which aimed create an input and output wish list for future BPS tools. Respondents listed the following requirements for simulation inputs. The frequency of votes is listed beside each requirement:

- more design guidelines (12/28)
- more defaults for code compliance (LEED, AHSRAE, Egyptian Standard) (20/28)
- flexible in use (8/28)
- Very easy to use (14/28)
- Easy to Learn (6/28)
- Sufficiently accurate (16/28)
- Informs design decisions (22/28)
- Use minimum amount of input (9/28)
- Match the cyclic design iterations (3/28)
- Adaptable to the users expertise (5/28)
- Interactive and giving warning if a design strategy or solution is needed (4/28)

Respodents listed the following requirments for simulation ouputs:

- Allows alternative comparison (16/28)
- Choose graph type (12/28)
- Parametric analysis & optmisation (22/28)
- Output interpretation (27/28)
- Calibration of output results (18/28)

Tools limitations in the Egyptian practice

Are there any barriers to your use of available tools and methods?

Participants from the three workshops found that the highest barrier to use BPS tools is the lack of informative support for decision making and lack of interoperability of geometry exchange with drawing (CAD) tools (Fig. 5). Some respondent pointed to the BIM technology as a solution to the interoperability problem. However, applying BIM technology is not possible during early design stages. The lack of integration of BPS tools within the design process, the steep learning curve and time consumption were considered by most participants as barriers.

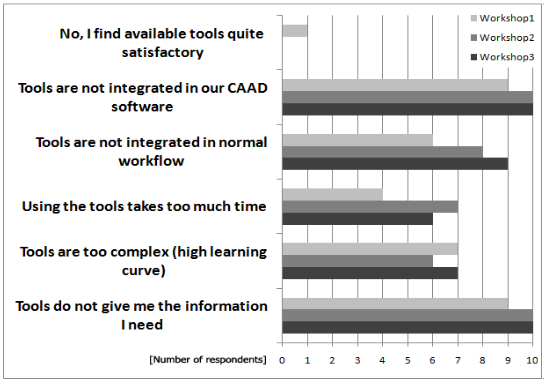

Figure 5: Responses given on barriers of using BPS tools

What are the barriers to the use of BPS tools for energy savings in your buildings? (Interest)

Almost all participants agreed that the client's lack of interest in efficiency was the main reason not to use BPS tools (Fig. 6). Surprisingly, when respondents were confronted with that graph they showed a serious interest in energy efficiency and sustainability but considered that the current practice and polices does not encourage this approach.

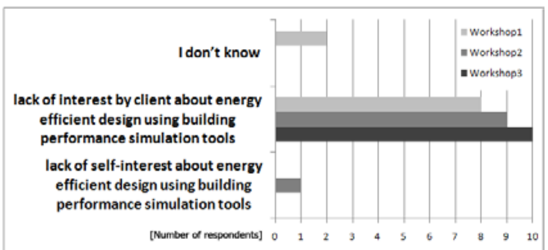

Figure 6, The most important barrier regarding interest

What are the barriers to the use of BPS tools for energy savings in your buildings? (Knowledge)

As shown in Figure 7, the lack of education and training in universities curricula on energy modelling was the most important knowledge barrier identified by architects and engineers. There are not avenues in Egypt to provide knowledge and experience in this field. There must be an emphasis on building science and building physics for architects and engineers in higher education. The second most important barrier is the lack of sufficient resources and knowledge on building performance and energy consumption buildings parallel to the lack of knowledge on model calibration. Not surprisingly, no single university in

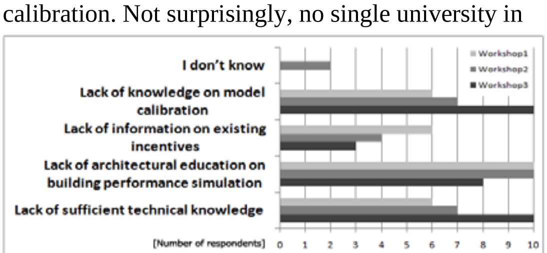

Figure 7, The most important barrier regarding knowledge

Egypt has a lab or research centre that studies building systems.

What are the barriers to the use of BPS tools for energy savings in your buildings? (Products)

This question aimed to identify the needs and adaptation requested to make existing tools suitable to the Egyptian users and market. As shown in Figure 8, the lack of resources or databases regarding building performance and including materials, weather files, schedules, benchmarks is the most important barrier that existing simulation products and packages do not support. Having a BPS tool in Arabic was considered as an important feature; however, most respondents consider it as an important option.

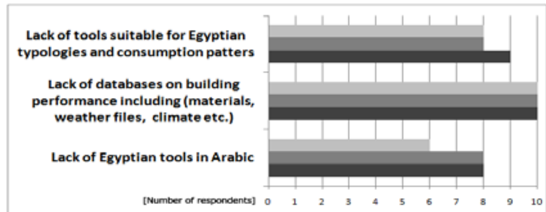

Figure 8, The most important barrier regarding products

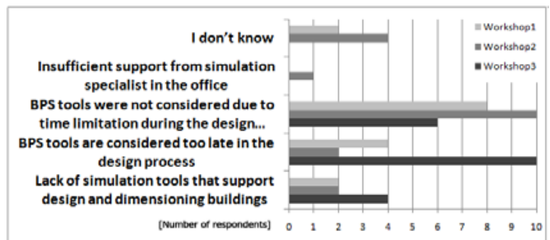

Figure 9, The most important barrier regarding process

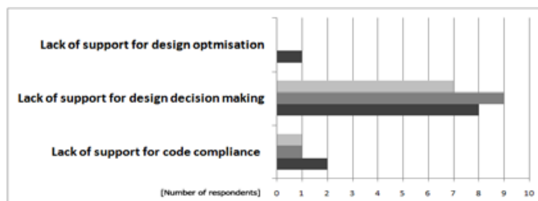

Figure 10, The most important barrier regarding support

What are the barriers to the use of BPS tools for energy savings in your buildings? (Process)

Most respondents agreed that the time consumption is the highest barrier to use BPS tools during the design (Fig. 9). The use of tools in late design phases was identified as the following highest barrier. During the discussion, respondents identified the Egyptian design approach as mono-disciplinary and linear, which postpones the use of BPS tools in later stages. In addition, architects mentioned that most tested tools are not concept oriented.

What are the barriers to the use of BPS tools for energy savings in your buildings? (Support)

Most respondents agreed that the design decision support is the highest barrier among users, followed by support for code compliance and design optimisation (Fig. 10).

DISCUSSION & CONCLUSION

It is clear that the participants have a low experience with BPS tool. In same time, two introduction days can not make the participant familiars with the surveyed tools. However, among all participants, there is recognition of the importance of BPS tools and design decision support tools in the building design community. According to participants, the aspiration of designers to create sustainable buildings by taking well informed decisions concerning, energy efficiency, passive strategies has been considerably growing in Egypt. The three workshops helped to identify gaps and barrier with the BPS sector in Egypt, which can be mainly summarized as follow:

- Lack of interest in energy efficiency and indoor environmental quality among project developers
- Lack of academic and professional education
- Lack of information on Egyptian building performance. The thermo-physical properties of typical Egyptian building materials and constructions are not available in digital databases. This includes properties of typical and special buildings (benchmarks), constructions and occupancy schedules used in Egypt.
- Difficulty of quality control and calibrating the simulation models.
- Lack of understanding of the simulation result or output and it consequences on design.
- Investments are needed for capacity building in the field of BPS for architects, engineers and urban planners.
- There is no available comprehensive dynamic BPS tool in Arabic addressing Egypt hot climate.

In addition to identify the critical needs that are related to BPS, we tried to identify a long-term vision or roadmap for the future of BPS. A post workshop report was produced to summarize the roadmap components targeting long-term needs as well as solutions. Under the three following titles, we summarize the report outcomes:

Figure 11: Workshop 2 participants filling a questionnaire form, August 2010

Practice: The workshop showed that the is a lack of industry knowledge about the power of BPS. In fact, the energy efficincy market in Egypt is estimated to be worth US$ 1 billion (UNDP 2010). Also Egypt is the highest-ranking nation in the Middle East and North Africa (MENA) region for energy efficency renewable investment potential. Thus, the Egyptian professional design community has a large opportunity for leaderships in environmental and energy efficient design. In order to comply with mandatory requirements, rating systems, verify and improve the indoor environmental quality of building the use of BPS is crucial.

Industry organization such as the Egyptian Green Building Council, HBRC, ASHRAE Cairo, the Egyptian Society of Architects, JCEE, MED-ENEC Cairo, GIZ Cairo, Egyptian Universities, Ministry of Electricity, large design and construction firms and manufacturers should start to play a role in influencing the BPS industry, and recognize the importance of collaborating with other activities taking place. By coordinating and building upon these organizations, we can truly capitalize on the opportunities that exist.

One of the interesting lessons of designing energy efficient buildings in Europe and North America is the application of Integrated Design Process (IDP), which encourages cross-disciplinary teamwork to deliver high performance buildings during all phases of the development. Despite that, the large majority of design firms in Egypt follow the conventional design process that generally limits the achievable performance and has a mainly linear structure; the IDP approach has now been applied to a wide variety of building types that were or will be LEED certified in Egypt. The IDP enforces testing of various design assumptions with energy simulations throughout the process, to provide relatively objective information on this key aspect of performance. This new challenge to the local design and construction techniques and building regulation requires innovative techniques to assist to spearhead this transition. BPS can play this role. Thus, the entry of simulation into a new market like Egypt is evident. The growing interest in verifying the performance regarding: energy, air quality, daylighting, comfort, life cycle analysis, cost, natural ventilation, fire and smoke prevention for complying with Egyptian standard and codes and LEED (ASHRAE 90.1-2007) rating system, can help the integration of BPS in practice, The integration of BPS will improve the efficiency of the built environment and to ensure quality of outdoor and indoor spaces.

Academia: The most solid message that came from the three workshops participants (architects & engineers) was the lack of academic education of BPS. In fact, Egypt has more than 56 architecture departments and 21 mechanical engineering departments in 33 public and private universities (MHE 2011). There are no curriculums for architectural engineering and no single university has degree programs that offer courses specially focused on BPS methods and tools. There is some tool-focused training in some undergraduate courses (Sherif 2008, Ahmed 2010 & Sabry 2010); however, there is no education vision in universities to teach foundational knowledge on building science or building physics for architects and engineers. More importantly, there is a strong resistance and doubts about the use of BPS in design among many professors. Probably this is due to the lack of knowledge and skills. However, investments are needed for capacity building in the field of BPS for architects, engineers, urban planners. There are many resources for sustainable environmental design and BPS including the Environmental Design in University Curricula and Architectural Training in Europe (EDUCATE) and (International Building Performance Simulation Association (IBPSA).

On the other hand, with the advent of internet many students are exposed to the international green and environmental design movement. Additionally, most Egyptian architecture students have been bombarded with lessons about integrating traditional environmental design in their future works (Asfour 2008). This is creating pressure on many architectural and engineering design schools. Some departments in Egypt (Mansoura Uni.) are starting to consider building physics as integral in their curriculum in association with the use of building performance simulation as integral for design assessment.

In order to produce graduates that fit in the IDP and use BPS to assess design academia should launch students design competitions, construct little demonstration units for monitoring and verification. BPS should be embraced by architectural and engineering schools as creative and innovative approaches that can assess the design and verify the performance. Involving the students in design competition such as Solar Decathlon or the yearly Hassan Fathy Competition while using BPS tools can create a change. Academic institutions should play active roles in providing the training and learning environment for the usage of BPS tools. Such training should start at the undergraduate level and in the form of continuing education for current design professionals.

Research: BPS evolved in research labs. In Europe and North America most universities that do offer BPS coursework are affiliated with labs or research centers. Therefore, it is essential that the local research and academic institutions, compile databases that enable, climatic analysis, materials, components data, standards and design details to be incorporated and made accessible to practising professionals rapidly and effectivley. This will improve the capabilities of the whole community as a whole community as a whole to design predictably low impact buildings.

There is a serious need in Egypt to fund research to create quality benchmark data for energy consumption in all building types (Gado 2009). There is a need to provide data on building energy use including, reliable weather data, plug loads and operational schedules. There is a need for test cells and case studies that can allow calibrated feedback to validate and support modelling adequately the latent heat associated with Egypt climates, and the mechanical equipment such as ceiling fans, used to accommodate these environmental conditions for thermal comfort (Khalil 2009 & Sheta 2010). This includes developing local simulation models and tools that cater for the Egyptian context and allow the development of interfaces that inform the decision making and help with output post-processing and interpretation.

Summary

According to the workshop participants, the use of BPS tools in Egypt is unexploited. Even the use of BPS tools for code compliance or regulatory conformance is not required. The current energy and fuel prices for consumers in Egypt is very low and does not reflect the real value of energy. However, after the Egyptian revolution the energy prices should increase to world market prices during the coming years. The role of government in this context, is to play a leadership role to promote R&D and incentive programs in the building industry and enforce the energy standard and/or provide incentives for code compliance, indoor enviornmental quality and building energy efficiency.

Figure 12: Problems facing the Egyptian Design Practice,

In the same time, Egypt cannot improve its buildings quality and have low impact buildings if there are no tools that enable designers to make better decisions during the design process. The Egyptian professional design commmunity can not improve the environmental impact of buildings and compete regionally an inetrnationally if the loop between building design operation and perfromance is not closed (Fig. 12) . To ensure that, guidance using BPS tools will be essential. BPS tools are required to help designers predict how buildings will perform in use, and to support the construction and operation of buildings. The authors hope that the information gathered in this workshops will be a starting point for encouraging simulation developers and users to talk more. The complete list of ideas generated during the workshops is available from the authors.

It might be intersting to establish IBPSA affiliation in Egypt by a small group of scholars and professionals who are advocates of integrating simulation into the industry of building construction. The objective will be providing knowledge transfer among researchers and practioners. IBPSA-Egypt can be responsible of organising conferences, symposiums and workshops concerning modelling and simulation. This can allow training for Egyptian BPS professionals and also help in compiling data on climate, building components and materials. Present practical case studies and research projects.

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APPENDIX A: LIST OF PARTICIPANTS

Workshop 1 was conducted 01-03/08/2010, workshop 2 was conducted 04-06/08/2010 and workshop3 was conducted 08-10/08/2010. A list of participants is provided in the link below:

http://perso.uclouvain.be/shady.attia/WorkshopIntro/StudentGallery.html

APPENDIX B: QUESTIONNAIRES

http://perso.uclouvain.be/shady.attia/WorkshopIntro/Files/Surveys.pdf